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TECH. NOTE  
MET.235

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MET.235

**FC**

**ROYAL AIRCRAFT ESTABLISHMENT**  
FARNBOROUGH, HANTS

TECHNICAL NOTE No: MET.235

**THE CORROSION RESISTANCE  
OF BINARY MAGNESIUM-LITHIUM  
ALLOYS IN SHEET FORM**

by

**H.G.COLE**

**FEBRUARY, 1956**

560130
1 MAY 1956

MINISTRY OF SUPPLY, LONDON, W.C.2

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U.D.C. No. 669.721.5.884 : 620.193.27

Technical Note No. Met.235

February, 1956

ROYAL AIRCRAFT ESTABLISHMENT, FARNBOROUGH

The corrosion resistance of binary magnesium-lithium  
alloys in sheet form

by

H. G. Cole

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RAE Ref. Mat.M4A/11301/HGC  
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SUMMARY

Corrosion tests by total immersion in 3% sodium chloride solution and by intermittent sea water spray have been made on sheets rolled from a series of binary magnesium-lithium alloys low in sodium. Alloys containing up to 10% lithium by weight had a corrosion resistance approximately equal to that of magnesium -1.5% manganese alloy sheet and were equally well protected by conventional protective treatments.

At lithium contents of 12% and over, corrosion resistance fell rapidly.

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## 1 Introduction

At one time great hopes were entertained that alloys based on the magnesium lithium system could be developed which would be strong, ductile and light. These hopes have been disappointed by the metallurgical instability of the alloys, but it is thought worth while to put on record an investigation into the corrosion resistance of binary magnesium-lithium alloys.

This Note describes the determination of the intrinsic corrosion resistance of a series of binary magnesium-lithium alloys and of the efficiency of standard protective treatments applied to them. It is hoped that the information will be useful for predicting the probable corrosion behaviour of more complex alloys, and for selecting a cladding alloy, should one be required, to protect a stronger but less resistant magnesium-lithium base core.

## 2 Preparation of specimens

Sheet specimens were rolled at R.A.E. from cast slabs made at the University College of South Wales, Cardiff, by Professor W. R. D. Jones and Mr. Willis, to whom grateful acknowledgement is made. Nine casts were prepared containing respectively 0, 2, 4, 6, 8, 10, 12, 15 and 18 per cent of lithium by weight.

The alloys were prepared by melting lumps of high purity magnesium, pickled in dilute sulphuric acid, in an uncoated steel crucible under a stream of argon purified by passage through pyrogallol and then through concentrated sulphuric acid. High purity lithium was added through a hole in the crucible lid. The melt was stirred with a steel rod for five minutes and the temperature raised to 700°C. The melt was then pre-solidified, the temperature being allowed to drop to 550°C. The temperature was then raised briefly to 725°C, allowed to cool to 700°C, and the metal cast under argon with surface skimming into an N.P.I. steel book mould 7" x 6" x 1" dressed with French chalk and boric acid and preheated to 100°C.

The slabs were cut in half across their width and a half slab of each composition was rolled to 16 gauge sheet by the following procedures:-

0, 2% Li Hot rolled at 400°C, later at 380°C by 0.01" passes at first, later by 0.005" passes from 0.9" to 0.075". Annealed at 380°C then cold rolled by 0.01" passes to 0.065". Slight edge cracking occurred on the pure magnesium during the cold rolling.

4% Li Hot rolled at 400°C, later at 380°C, by 0.01" passes from 0.9" to 0.085". Annealed at 380°C, then cold rolled by 0.005" passes to 0.065".

6 and 8% Li Hot rolled at 300°C, later at 350°C by 0.01" passes to 0.25". Cold rolled by 0.01" passes to 0.065". The 6% Li alloy was annealed twice at 300°C during the cold rolling.

10% Li Hot rolled at 300°C, later at 350°C by 0.02" passes from 0.9" to 0.25". Cold rolled by 0.015", later 0.01", passes to 0.065".

12, 15 and 18% Li Cold rolled by 0.02" passes from 0.9" to 0.065".

General notes on rolling The 0 to 10% Li slabs were rolled as hard and at as low a temperature as seemed possible. Incipient cracking appeared from time to time; the affected parts were filed smooth. The rolls were used dry; for hot rolling, the rolls were heated to 130-150°C.

The compositions by analysis of the sheets are given in Table I.

Specimens of size 4" x 1 $\frac{1}{4}$ " were cut from the sheets and cleaned by rubbing with moist pumice powder. The following protective treatments were applied:-

Chromate treatment in bath iii of D.T.D.911A (0 to 6% Li at pH 6.00, 8% Li at pH 5.95, 10 and 12% Li at pH 5.90, 15 and 18% Li at pH 6.05).

High Duty Alloys anodic treatment, B.P.543,726

Ditto zinc chrome sealed, B.P.570,054

Swabbed with 10% selenious acid solution.

Some of the specimens were then painted with two spray coats of oil type zinc chrome primer followed by one spray coat of mat black cellulose finish to D.T.D.754.

Two types of corrosion test were used. In the first, unprotected specimens (triplicates) were totally immersed for 83 days in 3% sodium chloride solution at 25°C. In the second, which included all the protected specimens, the specimens (duplicates) were hung by glass hooks from glass rods in a covered shed open to the air on one side, and sprayed with natural sea water three times per working day.

The corroded specimens were brushed under running water to remove gross corrosion product and were then immersed overnight in a cold 10% solution of ammonium chromate through which a stream of air was bubbled. This treatment removes the last traces of corrosion product without appreciable effect on the metal, protective treatment or paint. The cleaned specimens were weighed, and the loss of weight calculated as mg/cm<sup>2</sup> per sq cm per day for the totally immersed specimens, and grms per sq dm per year for the sprayed specimens.

### 3 Results

A selection of the results is shown in graphical form in Fig.1. The results plotted for the sprayed unpainted specimens 2 to 12% Li are true mean weight losses for an exposure of one year; the sprayed painted specimens 2 to 12% Li were exposed for 28 months and the results have been calculated to one year for convenience, assuming a linear rate of corrosion. This assumption is not correct, but is not misleading in the present case where broad comparisons are being made. The 15 and 18% Li alloys showed poor corrosion resistance, and were exposed for much shorter periods; once again, amounts of corrosion have been calculated to the standard periods.

The results are plotted against the actual lithium contents of the alloys. They show that binary alloys in the range 2 to 10% have a corrosion resistance and response to protective treatment roughly equal to that of magnesium-manganese alloy sheet, a material usually considered to have very fair corrosion resistance. At 11.5% Li, the corrosion resistance was beginning to decline, and at 15.5 and 17.5% Li was very low.

Even at 15.5% Li, however, a full protective scheme of chromate treatment plus paint gave protection sufficient to make the alloy usable under mild conditions.

Unprotected cast blocks of the 15.5% and 17.5% alloys corroded steadily during storage in the laboratory at a rate estimated to be about 0.5 mm per year. The corrosion of these alloys, both as cast blocks and as rolled sheet was laminar, large flakes of corrosion product falling loose from time to time.

Magnesium-lithium binary alloys up to 5.7% lithium consist of a solid solution of lithium in hexagonal magnesium, from 5.7% to 10% lithium of an alpha-beta structure and from 10% lithium of a beta solid solution of magnesium in cubic lithium. The present results showed that the corrosion resistance of alloys of increasing lithium content was quite high up to the formation of the single beta phase. As further lithium was dissolved into the beta phase, however, the corrosion resistance declined rapidly.

Further results not included in Fig.1 showed that the HDA anodic treatment gave rather less protection to the alloys than bath iii chromate treatment, but that the chromate sealed anodic treatment gave protection approximately equal to bath iii. Swabbing with 10% selenious acid and the Dow No.7 treatment also gave protection about equal to bath iii.

#### 4 Conclusions

Corrosion tests by total immersion in 3% sodium chloride solution and by intermittent sea water spray have been made on magnesium-lithium binary alloys low in sodium. Binary alloys containing lithium up to 10% by weight had a corrosion resistance approximately equal to that of magnesium 1.5% manganese alloy sheet, and were equally well protected by conventional protective treatments.

At lithium contents of 12% and over, corrosion resistance fell rapidly.

#### 5 Further developments

None proposed.

#### Attached

Table I  
Drg. No. Mat 15096  
Detachable abstract cards

#### Advance distribution

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D Mat RD(A) 3  
WR(D) Met  
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Mat RD 3A Tech Records

DDI (Mat) AID Harefield  
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DD/A  
Pats 1 RAE  
Head of Structures Dept  
Head of Metallurgy Dept  
Library

100



TABLE ICompositions by analysis of alloys tested

Indent: No.	Type	Percentage composition by weight					
		Li	Na	Fe	Cu	Others	Mg
6N	Pure mg	-	0.010	0.007	0.0025	< 0.003 Si < 0.002 P < 0.002 Mn < 0.0005 Ni	Rem
6O	2% Li	1.98	0.0070	0.003	0.001		"
6P	4%	3.99	0.0077	0.002	0.0015		"
6Q	6%	5.48	0.0062	0.002	0.0015		"
6R	8%	7.68	0.0063	0.002	0.002		"
6S	10%	9.74	0.0094	0.002	0.0015		"
6T	12%	11.44	0.0048	0.004	0.0015		"
6U	15%	15.45	0.0031	0.002	0.002		"
6V	18%	17.53	0.0031	0.002	0.0015		"
5Z	D.T.D. 118, M1	-	-	0.021	0.003	1.3 Mn 0.010 P 0.010 Si 0.003 Ni	"

FIG. 1.

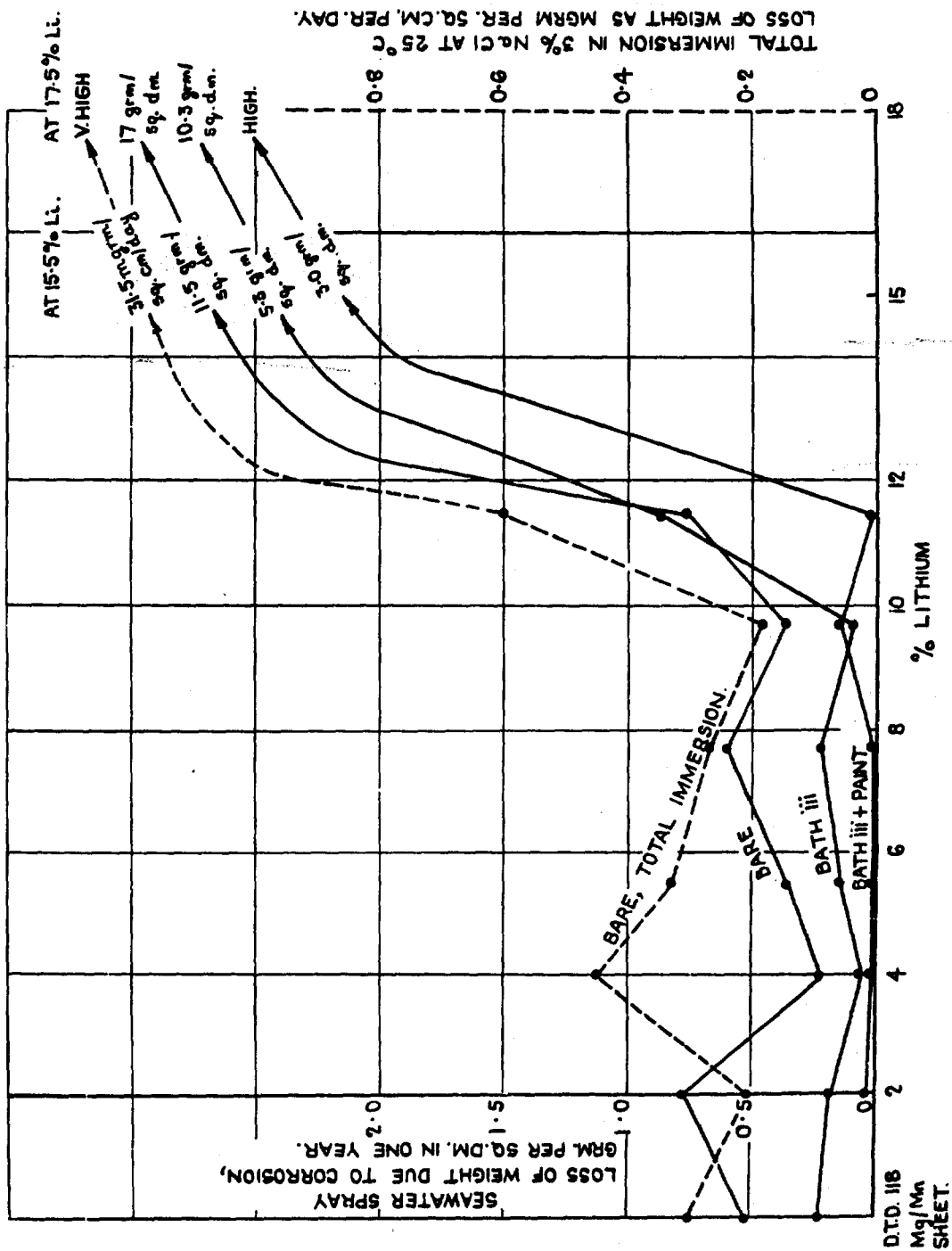


FIG. 1. CORROSION TEST RESULTS.

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<p align="center">UNCLASSIFIED</p> <p>Royal Aircraft Est. Tech. Note Met.235 1956.2 Cole, H. G.</p> <p>669.721.5.884: 620.193.27</p> <p>THE CORROSION RESISTANCE OF BINARY MAGNESIUM-LITHIUM ALLOYS IN SHEET FORM</p> <p>Corrosion tests by total immersion in 3% sodium chloride solution and by intermittent sea water spray have been made on sheets rolled from a series of binary magnesium-lithium alloys low in sodium. Alloys containing up to 10% lithium by weight had a corrosion resistance approximately equal to that of magnesium -1.5% manganese alloy sheet and were equally well protected by conventional protective treatments.</p> <p>At lithium contents of 12% and over, corrosion resistance fell rapidly.</p> <p align="center">UNCLASSIFIED</p>	<p align="center">UNCLASSIFIED</p> <p>Royal Aircraft Est. Tech. Note Met.235 1956.2 Cole, H. G.</p> <p>669.721.5.884: 620.193.27</p> <p>THE CORROSION RESISTANCE OF BINARY MAGNESIUM-LITHIUM ALLOYS IN SHEET FORM</p> <p>Corrosion tests by total immersion in 3% sodium chloride solution and by intermittent sea water spray have been made on sheets rolled from a series of binary magnesium-lithium alloys low in sodium. Alloys containing up to 10% lithium by weight had a corrosion resistance approximately equal to that of magnesium -1.5% manganese alloy sheet and were equally well protected by conventional protective treatments.</p> <p>At lithium contents of 12% and over, corrosion resistance fell rapidly.</p> <p align="center">UNCLASSIFIED</p>
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